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Probing Charm Production in Cold Nuclear Matter with the CBM Proton Beam Program

The Compressed Baryonic Matter (CBM) experiment at FAIR, with its unprecedented rate capabilities and precision vertexing, offers a unique opportunity to advance charm physics through its dedicated proton beam program. A central objective of this program is to investigate the production and propagation of charm hadrons in cold nuclear matter. Such studies will provide indispensable baseline measurements for heavy-ion collisions and deliver novel insights into the microscopic dynamics of the strong interaction.

The combination of excellent tracking, robust particle identification, and ultra-fast readout in CBM will facilitate high-precision measurements of charm production cross sections, nuclear modification factors, and flow observables at interaction rates beyond current experimental reach. These measurements are crucial for disentangling cold nuclear matter effects from those of the hot and dense medium created in heavy-ion collisions. Ultimately, the CBM proton program will refine our understanding of parton energy loss, hadronization mechanisms, and the manifestation of the strong force across the transition from hadronic to partonic degrees of freedom.

Exploiting a high-intensity proton beam on a variety of fixed targets, CBM will access rare charm probes—including open charm mesons (D^0, $D^\pm$), charm baryons (Λc), and hidden charm states (J/ψ, ψ'). The Micro Vertex Detector (MVD), with a decay-vertex resolution of about 50 μm, enables precise reconstruction of open charm decays. In this work, we demonstrate the performance of open charm meson and baryon reconstruction using the KFParticle Finder package, and discuss the challenges of primary vertex determination in events with multiple high-momentum charm particles.

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